11-21-00

A

Practitioner's Docket No. 297-009947-US(PAR) **PATENT**

Preliminary Classification:
Proposed Class:
Subclass:

NOTE: "All applicants are requested to include a preliminary classification on newly filed patent applications. The preliminary classification, preferably class and subclass designations, should be identified in the upper right-hand corner of the letter of transmittal accompanying the application papers, for example 'Proposed Class 2, subclass 129.'" M.P.E.P. § 601, 7th ed.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

NEW APPLICATION TRANSMITTAL

Transmitted herewith for filing is the patent application of

Inventor(s): Juha NURMINEN

WARNING: *37 C.F.R. § 1.41(a)(1) points out:*

"(a) A patent is applied for in the name or names of the actual inventor or inventors.

"(1) The inventorship of a nonprovisional application is that inventorship set forth in the oath or declaration as prescribed by § 1.63, except as provided for in § 1.53(d)(4) and § 1.63(d). If an oath or declaration as prescribed by § 1.63 is not filed during the pendency of a nonprovisional application, the inventorship is that inventorship set forth in the application papers filed pursuant to § 1.53(b), unless a petition under this paragraph accompanied by the fee set forth in § 1.17(i) is filed supplying or changing the name or names of the inventor or inventors."

For (title): IMPROVEMENT OF SIGNAL QUALITY

CERTIFICATION UNDER 37 C.F.R. § 1.10*
(Express Mail label number is mandatory.)
(Express Mail certification is optional.)

I hereby certify that this New Application Transmittal and the documents referred to as attached therein are being deposited with the United States Postal Service on this date November 20, 2000, in an envelope as "Express Mail Post Office to Addressee," mailing Label Number EL627421003US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

Deborah J. Clark
(type or print name of person mailing paper)

Deborah J. Clark
Signature of person mailing paper

WARNING: *Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. § 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.*

WARNING: *Each paper or fee filed by "Express Mail" **must** have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. § 1.10(b).*
*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

1. Type of Application

This new application is for a(n)

(check one applicable item below)

☒ Original (nonprovisional)

☐ Design

☐ Plant

WARNING: Do not use this transmittal for a completion in the U.S. of an international Application under 35 U.S.C. § 371(c)(4), unless the international Application is being filed as a divisional, continuation or continuation-in-part application.

WARNING: Do not use this transmittal for the filing of a provisional application.

NOTE: If one of the following 3 items apply, then complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF A PRIOR U.S. APPLICATION CLAIMED and a NOTIFICATION IN PARENT APPLICATION OF THE FILING OF THIS CONTINUATION APPLICATION.

☐ Divisional.

☐ Continuation.

☐ Continuation-in-part (C-I-P).

2. Benefit of Prior U.S. Application(s) (35 U.S.C. §§ 119(e), 120, or 121)

NOTE: A nonprovisional application may claim an invention disclosed in one or more prior filed copending nonprovisional applications or copending international applications designating the United States of America. In order for a nonprovisional application to claim the benefit of a prior filed copending nonprovisional application or copending international application designating the United States of America, each prior application must name as an inventor at least one inventor named in the later filed nonprovisional application and disclose the named inventor's invention claimed in at least one claim of the later filed nonprovisional application in the manner provided by the first paragraph of 35 U.S.C. § 112. Each prior application must also be:

(i) An international application entitled to a filing date in accordance with PCT Article 11 and designating the United States of America; or

(ii) Complete as set forth in § 1.51(b); or

(iii) Entitled to a filing date as set forth in § 1.53(b) or § 1.53(d) and include the basic filing fee set forth in § 1.16; or

(iv) Entitled to a filing date as set forth in § 1.53(b) and have paid therein the processing and retention fee set forth in § 1.21(l) within the time period set forth in § 1.53(f).

37 C.F.R. § 1.78(a)(1).

NOTE: If the new application being transmitted is a divisional, continuation or a continuation-in-part of a parent case, or where the parent case is an international Application which designated the U.S., or benefit of a prior provisional application is claimed, then check the following item and complete and attach ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

WARNING: If an application claims the benefit of the filing date of an earlier filed application under 35 U.S.C. §§ 120, 121 or 365(c), the 20-year term of that application will be based upon the filing date of the earliest U.S. application that the application makes reference to under 35 U.S.C. §§ 120, 121 or 365(c). (35 U.S.C. § 154(a)(2) does not take into account, for the determination of the patent term, any application on which priority is claimed under 35 U.S.C. §§ 119, 365(a) or 365(b).) For a c-i-p application, applicant should review whether any claim in the patent that will issue is supported by an earlier application and, if not, the applicant should consider canceling the reference to the earlier filed application. The term of a patent is not based on a claim-by-claim approach. See Notice of April 14, 1995, 60 Fed. Reg. 20,195, at 20,205.

WARNING: When the last day of pendency of a provisional application falls on a Saturday, Sunday, or Federal holiday within the District of Columbia, any nonprovisional application claiming benefit of the provisional application must be filed prior to the Saturday, Sunday, or Federal holiday within the District of Columbia. See 37 C.F.R. § 1.78(a)(3).

☐ The new application being transmitted claims the benefit of prior U.S. application(s). Enclosed are ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

3. Papers Enclosed

A. Required for filing date under 37 C.F.R. § 1.53(b) (Regular) or 37 C.F.R. § 1.153 (Design) Application

11 Pages of specification

4 Pages of claims

4 Sheets of drawing

WARNING: DO NOT submit original drawings. A high quality copy of the drawings should be supplied when filing a patent application. The drawings that are submitted to the Office must be on strong, white, smooth, and non-shiny paper and meet the standards according to § 1.84. If corrections to the drawings are necessary, they should be made to the original drawing and a high-quality copy of the corrected original drawing then submitted to the Office. Only one copy is required or desired. For comments on proposed then-new 37 C.F.R. § 1.84, see Notice of March 9, 1988 (1990 O.G. 57-62).

NOTE: "Identifying indicia, if provided, should include the application number or the title of the invention, inventor's name, docket number (if any), and the name and telephone number of a person to call if the Office is unable to match the drawings to the proper application. This information should be placed on the back of each sheet of drawing a minimum distance of 1.5 cm. (5/8 inch) down from the top of the page . . ." 37 C.F.R. § 1.84(c)).

(complete the following, if applicable)

☐ The enclosed drawing(s) are photograph(s), and there is also attached a "PETITION TO ACCEPT PHOTOGRAPH(S) AS DRAWING(S)." 37 C.F.R. § 1.84(b).

☐ formal

☐ informal

B. Other Papers Enclosed

6 Pages of declaration and power of attorney

1 Pages of abstract

____ Other

4. Additional papers enclosed

☐ Amendment to claims

☐ Cancel in this applications claims _____ before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

☐ Add the claims shown on the attached amendment. (Claims added have been numbered consecutively following the highest numbered original claims.)

☒ Preliminary Amendment

☒ Information Disclosure Statement (37 C.F.R. § 1.98)

☒ Form PTO–1449 (PTO/SB/08A and 08B)

☒ Citations

- ☐ Declaration of Biological Deposit
- ☐ Submission of "Sequence Listing," computer readable copy and/or amendment pertaining thereto for biotechnology invention containing nucleotide and/or amino acid sequence.
- ☐ Authorization of Attorney(s) to Accept and Follow Instructions from Representative
- ☐ Special Comments
- ☐ Other

5. Declaration or oath (including power of attorney)

NOTE: A newly executed declaration is not required in a continuation or divisional application provided that the prior nonprovisional application contained a declaration as required, the application being filed is by all or fewer than all the inventors named in the prior application, there is no new matter in the application being filed, and a copy of the executed declaration filed in the prior application (showing the signature or an indication thereon that it was signed) is submitted. The copy must be accompanied by a statement requesting deletion of the names of person(s) who are not inventors of the application being filed. If the declaration in the prior application was filed under § 1.47, then a copy of that declaration must be filed accompanied by a copy of the decision granting § 1.47 status or, if a nonsigning person under § 1.47 has subsequently joined in a prior application, then a copy of the subsequently executed declaration must be filed. See 37 C.F.R. §§ 1.63(d)(1)–(3).

NOTE: A declaration filed to complete an application must be executed, identify the specification to which it is directed, identify each inventor by full name including family name and at least one given name, without abbreviation together with any other given name or initial, and the residence, post office address and country or citizenship of each inventor, and state whether the inventor is a sole or joint inventor. 37 C.F.R. § 1.63(a)(1)–(4).

☒ Enclosed

Executed by

(check ***all*** *applicable boxes)*

X☒ Inventor(s).

☐ legal representative of inventor(s). 37 C.F.R. §§ 1.42 or 1.43.

☐ joint inventor or person showing a proprietary interest on behalf of inventor who refused to sign or cannot be reached.

☐ This is the petition required by 37 C.F.R. § 1.47 and the statement required by 37 C.F.R. § 1.47 is also attached. *See* Item 13 below for fee.

☐ Not Enclosed.

NOTE: Where the filing is a completion in the U.S. of an International Application or where the completion of the U.S. application contains subject matter in addition to the International Application, the application may be treated as a continuation or continuation-in-part, as the case may be, utilizing ADDED PAGE FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION CLAIMED.

☐ Application is made by a person authorized under 37 C.F.R. § 1.41(c) on behalf of *all* the above named inventor(s).

(The declaration or oath, along with the surcharge required by 37 C.F.R. § 1.16(e) can be filed subsequently).

☐ Showing that the filing is authorized. *(not required unless called into question. 37 C.F.R. § 1.41(d))*

6. Inventorship Statement

WARNING: If the named inventors are each not the inventors of all the claims an explanation, including the ownership of the various claims at the time the last claimed invention was made, should be submitted.

The inventorship for all the claims in this application are:

☐ The same.

or

☐ Not the same. An explanation, including the ownership of the various claims at the time the last claimed invention was made,

☐ is submitted.

☐ will be submitted.

7. Language

NOTE: An application including a signed oath or declaration may be filed in a language other than English. An English translation of the non-English language application and the processing fee of $130.00 required by 37 C.F.R. § 1.17(k) is required to be filed with the application, or within such time as may be set by the Office. 37 C.F.R. § 1.52(d).

☒ English

☐ Non-English

☐ The attached translation includes a statement that the translation is accurate. 37 C.F.R. § 1.52(d).

8. Assignment

☒ An assignment of the invention to Nokia Mobile Phones Ltd.

☒ is attached. A separate ☒ "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or ☐ FORM PTO 1595 is also attached.

☐ will follow.

NOTE: "If an assignment is submitted with a new application, send two separate letters-one for the application and one for the assignment." Notice of May 4, 1990 (1114 O.G. 77-78).

WARNING: A newly executed "CERTIFICATE UNDER 37 C.F.R. § 3.73(b)" must be filed when a continuation-in-part application is filed by an assignee. Notice of April 30, 1993, 1150 O.G. 62-64.

9. Certified Copy

Certified copy(ies) of application(s)

Country	Appln. No.	Filed
Finland	19992540	26 November 1999
Country	Appln. No.	Filed
Country	Appln. No.	Filed

from which priority is claimed

☒ is (are) attached.

☐ will follow.

NOTE: The foreign application forming the basis for the claim for priority must be referred to in the oath or declaration. 37 C.F.R. § 1.55(a) and 1.63.

NOTE: This item is for any foreign priority for which the application being filed directly relates. If any parent U.S. application or International Application from which this application claims benefit under 35 U.S.C. § 120 is itself entitled to priority from a prior foreign application, then complete item 18 on the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED.

10. Fee Calculation (37 C.F.R. § 1.16)

A. ☒ Regular application

	CLAIMS AS FILED				
	Number filed		Number Extra	Rate	Basic Fee 37 C.F.R. § 1.16(a) $ 710.00
Total Claims (37 C.F.R. § 1.16(c))	19	− 20 =	0	× $ 18.00	0
Independent Claims (37 C.F.R. § 1.16(b))	3	− 3 =	0	× $ 80.00	0
Multiple dependent claim(s), if any (37 C.F.R. § 1.16(d))				+ $ 270.00	

☐ Amendment canceling extra claims is enclosed.

☒ Amendment deleting multiple-dependencies is enclosed.

☐ Fee for extra claims is not being paid at this time.

NOTE: If the fees for extra claims are not paid on filing they must be paid or the claims cancelled by amendment, prior to the expiration of the time period set for response by the Patent and Trademark Office in any notice of fee deficiency. 37 C.F.R. § 1.16(d).

Filing Fee Calculation $ 710.00

B. ☐ Design application
($ 320.00 –37 C.F.R. § 1.16(f))

Filing Fee Calculation $_____

C. ☐ Plant application
($ 490.00 –37 C.F.R. § 1.16(g))

Filing fee calculation $_____

11. Small Entity Statement(s)

☐ Statement(s) that this is a filing by a small entity under 37 C.F.R. § 1.9 and 1.27 is (are) attached.

WARNING: "Status as a small entity must be specifically established in each application or patent in which the status is available and desired. Status as a small entity in one application or patent does not affect any other application or patent, including applications or patents which are directly or indirectly dependent upon the application or patent in which the status has been established. The refiling of an application under § 1.53 as a continuation, division, or continuation-in-part (including a continued prosecution application under § 1.53(d)), or the filing of a reissue application requires a new determination as to continued entitlement to small entity status for the continuing or reissue application. A nonprovisional application claiming benefit under 35 U.S.C. § 119(e), 120, 121, or 365(c) of a prior application, or a reissue application may rely on a statement filed in the prior application or in the patent if the nonprovisional application or the reissue application includes a reference to the statement in the prior application or in the patent or includes a copy of the statement in the prior application or in the patent and status as a small entity is still proper and desired. The payment of the small entity basic statutory filing fee will be treated as such a reference for purposes of this section." 37 C.F.R. § 1.28(a)(2).

WARNING: "Small entity status must not be established when the person or persons signing the . . . statement can unequivocally make the required self-certification." M.P.E.P., § 509.03, 6th ed., rev. 2, July 1996 (emphasis added).

(complete the following, if applicable)

☐ Status as a small entity was claimed in prior application

_____ / _____, filed on _____, from which benefit is being claimed for this application under:

35 U.S.C. § ☐ 119(e),
☐ 120,
☐ 121,
☐ 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the statement in the prior application is included.

Filing Fee Calculation (50% of **A**, **B** or **C** above)

$_____

NOTE: Any excess of the full fee paid will be refunded if small entity status is established and a refund request are filed within 2 months of the date of timely payment of a full fee. The two-month period is not extendable under § 1.136. 37 C.F.R. § 1.28(a).

12. Request for International-Type Search (37 C.F.R. § 1.104(d))

(complete, if applicable)

☐ Please prepare an international-type search report for this application at the time when national examination on the merits takes place.

13. Fee Payment Being Made at This Time

☐ Not Enclosed

☐ No filing fee is to be paid at this time.
(This and the surcharge required by 37 C.F.R. § 1.16(e) can be paid subsequently.)

☒ Enclosed

☒ Filing fee $ 710.00

☒ Recording assignment
($40.00; 37 C.F.R. § 1.21(h))
(See attached "COVER SHEET FOR ASSIGNMENT ACCOMPANYING NEW APPLICATION".) $ 40.00

☐ Petition fee for filing by other than all the inventors or person on behalf of the inventor where inventor refused to sign or cannot be reached
($130.00; 37 C.F.R. §§ 1.47 and 1.17(i)) $ _____

☐ For processing an application with a specification in a non-English language
($130.00; 37 C.F.R. §§ 1.52(d) and 1.17(k)) $ _____

☐ Processing and retention fee
($130.00; 37 C.F.R. §§ 1.53(d) and 1.21(l)) $ _____

☐ Fee for international-type search report
($40.00; 37 C.F.R. § 1.21(e)) $ _____

NOTE: 37 C.F.R. § 1.21(l) establishes a fee for processing and retaining any application that is abandoned for failing to complete the application pursuant to 37 C.F.R. § 1.53(f) and this, as well as the changes to 37 C.F.R. §§ 1.53 and 1.78(a)(1), indicate that in order to obtain the benefit of a prior U.S. application, either the basic filing fee must be paid, or the processing and retention fee of § 1.21(l) must be paid, within 1 year from notification under § 53(f).

Total fees enclosed $ 750.00

14. Method of Payment of Fees

☒ Check in the amount of $ 750.00

☐ Charge Account No. _____ in the amount of $_____.

A duplicate of this transmittal is attached.

NOTE: Fees should be itemized in such a manner that it is clear for which purpose the fees are paid. 37 C.F.R. § 1.22(b).

15. Authorization to Charge Additional Fees

WARNING: *If no fees are to be paid on filing, the following items should not be completed.*

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges, if extra claim charges are authorized.*

[X] The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Account No. 16-1350:

[X] 37 C.F.R. § 1.16(a), (f) or (g) (filing fees)

[X] 37 C.F.R. § 1.16(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1.16(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

[X] 37 C.F.R. § 1.16(e) (surcharge for filing the basic filing fee and/or declaration on a date later than the filing date of the application)

[X] 37 C.F.R. § 1.17(a)(1)–(5) (extension fees pursuant to § 1.136(a)).

[X] 37 C.F.R. § 1.17 (application processing fees)

NOTE: ". . .A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

[ ] 37 C.F.R. § 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. § 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. § 1.28(b) requires "Notification of any change in status resulting in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying, . . . the issue fee. . . " From the wording of 37 C.F.R. § 1.28(b), (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

16. Instructions as to Overpayment

NOTE: ". . . Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

[X] Credit Account No. 16-1350

[ ] Refund

SEND ALL CORRESPONDENCE TO:
Clarence A. Green, Reg. No.: 24,622
PERMAN & GREEN, LLP
425 Post Road
Fairfield, Connecticut 06430

Reg. No. 24,622

Tel. No. (203) 259-1800

Customer No. 2512

SIGNATURE OF PRACTITIONER

Clarence A. Green

(type or print name of attorney)

PERMAN & GREEN, LLP

P.O. Address

425 Post Road, Fairfield, Connecticut 06430

☐ **Incorporation by reference of added pages**

(check the following item if the application in this transmittal claims the benefit of prior U.S. application(s) (including an international application entering the U.S. stage as a continuation, divisional or C-I-P application) and complete and attach the ADDED PAGES FOR NEW APPLICATION TRANSMITTAL WHERE BENEFIT OF PRIOR U.S. APPLICATION(S) CLAIMED)

☐ Plus Added Pages for New Application Transmittal Where Benefit of Prior U.S. Application(s) Claimed

Number of pages added _____

☐ Plus Added Pages for Papers Referred to in Item 4 Above

Number of pages added _____

☐ Plus added pages deleting names of inventor(s) named in prior application(s) who is/are no longer inventor(s) of the subject matter claimed in this application.

Number of pages added _____

☐ Plus "Assignment Cover Letter Accompanying New Application"

Number of pages added _____

☒ **Statement Where No Further Pages Added**

(if no further pages form a part of this Transmittal, then end this Transmittal with this page and check the following item)

☒ This transmittal ends with this page.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Express Mail No.: EL627421003US
In re Application of: Juha NURMINEN
SERIAL NUMBER: EXAMINER:
FILING DATE: Herewith ART UNIT:
TITLE: IMPROVEMENT OF SIGNAL QUALITY
ATTORNEY DOCKET NO.: 297-009947-US(PAR)

The Commissioner of Patents and Trademarks
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the above-identified, enclosed patent application as follows:

IN THE CLAIMS:

Please amend Claims 9 and 10 as shown below.

Claim 9, line 1, delete "or 8".

Claim 10, line 1, delete "or 8".

Remarks

Please enter this preliminary amendment prior to calculation of the fees.

Respectfully submitted,

26 Nov 2001

Clarence A. Green, Reg. No. 24,622 Date
Perman & Green, LLP
425 Post Road
Fairfield, CT 06430
(203) 259-1800
Customer No.: 2512

Improvement of signal quality

This invention relates in particular to a method for improving the quality of an audio signal. The invention also relates to an output stage with which the quality of an audio signal can be improved. In addition the invention relates to a mobile wireless terminal (also known and hereinafter referred to as mobile station) by means of an arrangement made in which the quality of an audio signal can be improved.

Several different types of amplifier have been developed for audio signal amplification. Audio amplifiers are conventionally classified and the different classes are denoted by letters A, B, AB, C, and D. It is typical of a conventional class A amplifier that it operates in the linear range whereby it is especially advantageously used in audio applications. The drawback of the class A amplifier is that it has a low efficiency for which reason it is seldom used in audio output stages. A class B amplifier has a high efficiency because of the typical push-pull operation, but in order to reduce the crossover distortion a class AB amplifier is almost always required which gives lower efficiency. The class AB amplifier represents a good compromise between the class A and class B amplifiers but it requires that the operating point of the amplifier stage does not drift according to temperature, for example. Therefore, a class C amplifier used in radio-frequency applications uses an operating point that makes the transistor non-conductive in the absence of an input signal, but in order to reduce distortion, resonating circuits are needed at the output. On the other hand, the efficiency and linearity of a class D amplifier are in principle good without operating point adjustment since the output stage acts only as a switch. A class D amplifier becomes fully conductive when an input signal is applied. A typical bridge-connected class D amplifier requires only a third of the operating power of a corresponding class AB amplifier with equal output power and distortion factor. A disadvantage is that the switching frequency of a class D amplifier has to be filtered from the output signal by means of a low-pass filter, but if the switching frequency is high enough the filtering will be simpler. A class D amplifier is typically used to amplify an analog signal, in which case the input signal of the amplifier is analog and the possible feedback signal is also a continuous analog signal. The feedback signal is usually taken from the low-pass filter output. In some recently developed class D output stages, the operation of which is based on pulse width modulation, as disclosed e.g. in the U.S. Patent No. 5,594,386 (Dhuyvetter), the analog feedback signal is generated by integrating the output pulses prior to possible low-pass filtering. However, the feedback method disclosed does not allow for pulse amplitude variation caused e.g. by fluctuations in the operating voltage and

therefore is not able to improve the quality of an audio signal by eliminating the resulting distortion. Thus it would be advantageous to use a class D amplifier directly in the processing of digital audio signals and, especially advantageously, the quality of the signal could be improved at the same time.

In modern mobile stations the digital audio signal is typically first converted into an analog signal, then amplified and only then fed to the loudspeaker. This is, however, impractical as such an arrangement involves a lot of wasted power. It is, indeed, more practical to feed direct to the loudspeakers the analog power generated from the amplified digital signal, whereby the quality of the signal can be improved. Such an arrangement can be achieved with a class D output stage, which means a circuit that comprises at least a class D amplifier to process the signal.

Fig. 1 shows a block diagram of a prior-art class D output stage. The block diagram shown comprises a sigma-delta modulator 101, a class D amplifier circuit 102 and an LC filter 103. In prior-art solutions the digital word at the input IN, which here refers to a set of parallel bits generated from an incoming digital serial or parallel word or pulse-coded message, is fed to the sigma-delta modulator 101 which converts the word fed into the input IN into a pulse train in which the pulse density corresponds to the value of said word fed to the input IN. This pulse train is fed to the class D amplifier circuit 102 which processes the pulse train so as to amplify it in a predetermined manner. For example, pulses indicating high bits may be amplified either to the maximum operating voltage of the amplifier or to ground potential, depending on what has been determined. Pulses indicating low bits are amplified in a corresponding predetermined manner. The amplified pulse train is fed in accordance with the prior art to a low-pass filter, in this case LC filter 103. A driver circuit 102 feeds the signal through the filter 103 direct to a load. By means of the filter 103 it is possible at least partly to remove from the pulse train switching-frequency interference and quantization noise generated in particular in the sigma-delta modulator 101.

The prior-art solutions described above have some disadvantages. First, prior-art solutions are highly susceptible to supply voltage fluctuations. As the supply voltage fluctuates the output audio signal becomes distorted. The distortion is typically of the third order and, additionally, the supply voltage fluctuation results in a noise component that increases the output impedance. Second, the prior-art solutions typically do not have error correction by means of which the disturbances caused by the power stage and external load could be mitigated and removed. If there is error correction, it is based on the use of analog signals. Furthermore, in prior-art

solutions the linearity of the output signal of the power stage is not accurate enough for all applications. This is especially problematic in cases in which the supply voltage is unregulated so that it may fluctuate to a great extent.

An object of this invention is to reduce the above-described problems associated with the prior art and to provide an output stage by means of which the quality of an audio signal can be improved.

The objects of the invention are achieved by providing an audio output stage with feedback realized by digital signals, by means of which feedback the quality of a signal can be improved by digitally controlling the operation of a modulating circuit.

The method according to the invention for improving the quality of the output signal of an output stage, which comprises at least a modulator circuit, is characterized in that

- a signal generated in the output stage, which signal is proportional to a previous digital input signal, is compared by means of feedback to the digital input signal of the output stage in order to generate a digital control signal, and

- the operation of said modulator circuit is controlled by means of said digital control signal.

The output stage according to the invention for improving the quality of an output signal, which output stage comprises

- a modulator circuit for modulating a digital input signal,

- an amplifier circuit for amplifying the modulated signal,

- a filter circuit for filtering the modulated and amplified signal,

is characterized in that the output stage further comprises a comparator circuit for comparing the digital input signal and a signal generated in the output stage, which signal is proportional to a previous digital input signal, and for generating a digital control signal for the modulator circuit.

The mobile station according to the invention, which mobile station comprises an output stage for processing a received audio signal, is characterized in that the output stage in the mobile station comprises

- a first means to modulate a digital signal,

- a second means to amplify a modulated signal,

- a third means to filter a modulated and amplified signal,

- a fourth means to generate a digital control signal by comparing the input signal to a signal generated in the output stage, which signal is proportional to a previous digital input signal, and by processing the signal which is the result of the comparison in such a manner that it is converted into a digital control signal suitable for the first means.

Advantageous embodiments of the invention are presented in the dependent claims.

In the arrangement according to the invention feedback is arranged at the output stage. By means of the feedback it is possible to improve the quality of the output signal of the output stage. The output stage advantageously comprises a modulator circuit, amplifier circuit, filter circuit and a comparator circuit. The input signal is modulated, after which the signal is amplified and filtered. Advantageously the output signal of the amplifier circuit is brought by the feedback to the comparator circuit where the signal is compared to the current input signal of the output stage. In accordance with a second arrangement the feedback is taken from the filter circuit output. On the basis of said comparison a difference signal is advantageously generated and then processed so as to provide a control signal suitable for the modulator circuit. The control signal is used to change the settings in the modulator circuit, whereby errors generated in the processing of the previous input signal are taken into account in the modulation of the input signal. Said feedback signal is made digital for the modulator circuit.

The invention will now be described in more detail with reference to the accompanying drawings wherein

Fig. 1 shows a prior-art class D output stage,

Fig. 2 shows a flow diagram of the method according to the invention,

Fig. 3a shows an input signal,

Fig. 3b shows a feedback signal,

Fig. 3c shows a difference signal before processing,

Fig. 4 shows a first class D output stage according to the invention,

Fig. 5 shows another class D output stage according to the invention,

Fig. 6 shows a sigma-delta modulator according to the invention, and

Fig. 7 shows a mobile station according to the invention.

Like elements in the figures are denoted by like reference designators. Fig. 1 was discussed above in connection with the description of the prior art.

Fig. 2 shows a flow diagram of the method according to the invention. In accordance with the method, a digital input signal is processed 201 in the first step so as to be suitable for the output means. The input signal may be e.g. a digital word or pulse-coded message which is converted e.g. by means of pulse width modulation into a bit stream. In addition, the input signal may be inverted and amplified, for example. Furthermore, the signal may be filtered in connection with the processing. At an advantageous point, say after the amplification, the processed input signal is sampled, thus obtaining a feedback signal 202 which is advantageously processed e.g. by filtering in such a manner that the bandwidth of the feedback signal corresponds to the bandwidth of the original input signal. The feedback may also be taken after the filtering. The processed feedback signal is compared to the input signal and on the basis of the comparison a difference signal is generated 203. The comparison is performed advantageously more than once for every input signal word since in the arrangement according to the invention the sampling frequency of the feedback signal is advantageously higher than the updating frequency of the input word. Advantageously the difference signal is processed in such a manner that the rate and direction of change of the difference signal can be determined. This can be realized e.g. by first integrating and then differentiating said feedback signal. Said information about the rate and direction of change of the difference signal is advantageously used for estimating and predicting the difference signal, whereby a control signal is generated by modifying the value of the difference signal on the basis of the rate and direction of change of the difference signal, 204. The control signal is used in the next step 205 in the processing of the input signal in such a manner that it is used to control the units processing the input signal. It is obvious to a person skilled in the art that in the method according to the invention the control signal is used in an attempt to remove the errors generated in the input signal during the processing by comparing the feedback signal time and again to the instantaneous input signal. So, by controlling at least one processing unit it is thus possible to compensate for an error in the output signal. It is obvious to one skilled in the art that from the temporal point of view the control signal is generated from the value

of a signal that is prior to the signal affected by the control signal. Thus, in a way, the method according to the invention predicts the development of the difference signal error during the generation of the control signal and corrects it as quickly as possible by means of said control signal, but using a control signal value such that the feedback will not result in self-oscillation.

It is obvious to a person skilled in the art that since the feedback signal is updated more frequently than the input word, reference points can be created in between the input word changing points. This is illustrated in Figs. 3a to 3c which schematically show the development of the input signal, feedback signal and difference signal in the case of an open loop. Fig. 3a shows the update points a0, b0, c0, d0 of a digital input signal, such as a digital input word. Correspondingly, Fig. 3b shows the update points a1, a2, b1, c1, c2, d0, d1, d2 of the feedback signal, which is updated more frequently than the input signal. Fig. 3c shows the development of the difference signal in the case of an open loop. In practice, i.e. in the case of a closed loop, the general amplitude of the difference signal is naturally significantly smaller as it is just the purpose of the feedback to minimize the difference signal. It is obvious to one skilled in the art that the signals shown in Figs. 3a to 3c are not directly connected with any particular embodiment of the invention but are shown here just for the purpose of illustrating the invention.

Advantageously the signals described above are in sampled form in the memory of a digital signal processor or the like, and the necessary filtering and processing and the comparison in order to generate the difference signal as well as the processing of the difference signal are realized in software in a digital signal processor.

In a method according to the invention the difference signal is used to change at least one reference level in the converting circuit. By changing the reference level it is possible to avoid extra delays, whereby the output signal error can be corrected faster. Then also the difference signal determined will better represent the current input signal. The idea in the method according to the invention is that e.g. in a case where the output signal value is greater than the input signal value, a negative difference signal is generated. This negative difference signal is e.g. summed to the reference level of the converting circuit, thus making said reference level lower. By reference level it is meant here the level in the converting circuit at which the converting circuit interprets the input signal value as one. As the reference level decreases the reference level is reached with a lower input signal value, whereby the output signal value decreases and, hence, the difference signal decreases, too. If, on the other hand, the output signal value is smaller than the input signal value, the

reference level is increased, whereby the output signal value increases and the difference signal decreases. It is obvious to a person skilled in the art that the changing of the reference level may be arranged in some other manner than what is described.

Fig. 4 shows an output stage block diagram according to a first embodiment of the invention. The output stage comprises at least a modulator circuit 301, amplifier circuit 302, filter circuit 303 and comparator circuit 305. The input signal IN is arranged so as to be fed to the modulator circuit 301. In this exemplary embodiment the input signal IN is a numerical value represented by a digital word. The width of the word may be freely chosen according to the requirements of the particular applications. The modulator circuit 301 is e.g. a sigma-delta converter by means of which the digital word can be converted, using e.g. pulse density modulation, into a pulse train, the pulse values being determined on the basis of the pulse density. As known, the sigma-delta converter has an internal reference level on the basis of which the converter determines the output bit value. The output signal, or the pulse train, from the modulator 301 is taken to the amplifier circuit 302, which in this exemplary embodiment is a class D amplifier. The amplifier circuit 302 amplifies the signal e.g. in such a manner that it raises the voltage level of the pulses indicating a one, i.e. the more dense pulse train, for example, to the supply voltage of the amplifier circuit 302, and drops the pulse density indicating a zero to ground potential. It is obvious to one skilled in the art that the voltage levels representing the pulse densities may also be chosen otherwise. The output signal from the amplifier circuit 302 is a pulsed analog signal which, when suitably filtered in the filter circuit 303, can be fed to the output means, such as e.g. loudspeakers in the case of an audio signal. Filtering can be carried out using e.g. a low-pass filter implemented with an LC circuit.

The exemplary embodiment shown in Fig. 4 has a feedback loop in which the feedback signal 304 is taken from the output of the amplifier circuit 302. The feedback signal 304 is fed to the comparator circuit 305. The feedback signal 304 is filtered in such a manner that operations in the comparator circuit 305 are carried out only on signal frequencies corresponding to the input signal IN. The comparator circuit 305 comprises a first means 314 to filter said feedback signal 304, which is analog, to a frequency range corresponding to the input signal. The comparator circuit 305 comprises a second means 308 to convert the filtered analog signal into a digital signal. Advantageously said means 308 is an A/D converter, for example. The comparator circuit further comprises a means 309 with which bits can be added to said digital signal so as to make it correspond to the input signal regarding the number of

bits. A sample signal 306 is taken into the comparator circuit 305 from the current input signal IN. Advantageously the comparator circuit 305 comprises a means 310 to synchronize the feedback signal with the output stage input signal IN. It is obvious to a person skilled in the art that advantageously the number of bits in the sample signal 306 corresponds to the bit width of one input word. The comparator circuit 305 advantageously comprises a means 311 to compare the values of the sample signal 306 and feedback signal 304 so that a difference signal is generated as a result of that comparison. The comparator circuit 305 further comprises a means 312 to process, e.g. by means of integration and differentiation, the difference signal, so that these operations yield the rate and direction of change of the difference signal at that moment. By comparing this to the results of earlier differentiations it is possible to determine the direction of change of the difference signal for a longer period of time. The comparator circuit 305 also comprises a means 313 to change the processed difference signal into a control signal 307 suitable for the modulator circuit 301. Advantageously the value of the control signal 307 is based on the difference signal change information obtained from the processing. By means of the control signal 307 the reference levels of the modulator circuit 301 can be processed such that the output signal of the amplifier circuit 302 better represents the input signal IN. It is obvious to one skilled in the art that the arrangement according to the invention can be used to predict the rate and direction of change of the difference signal. Thus the difference signal is used so as to make the output signal follow the input signal, whereby errors caused by signal modulations and amplifications can be reduced.

Fig. 5 shows a second advantageous embodiment of the invention. In this embodiment the class D output stage comprises a modulator circuit 301, amplifier circuit 302, filter circuit 303 and a comparator circuit 305. The input signal IN is processed in this exemplary embodiment in the same way as in the arrangement according to Fig. 4. In the first step the input signal IN is modulated e.g. by means of pulse density modulation into a pulse train in which the pulse density represents the input bit value. Such modulation can be realized e.g. with a sigma-delta converter having an internal reference level on the basis of which the input signal value is converted into a pulse train. The output of the modulator circuit 301 is taken to the amplifier circuit 302, which may comprise a class D amplifier, for example. In the amplifier circuit 302 the pulses in the pulse train are amplified e.g. in such a manner that the voltage level of the pulses in a dense pulse train is increased to the supply voltage of the amplifier circuit 302 and the level of the other pulses is dropped to ground potential. It is obvious to one skilled in the art that the pulse train amplification may also be

arranged in some other way. The output from the amplifier circuit 302 is further taken to the filter circuit 303 where the signal is suitably filtered for the output means. Advantageously filtering removes at least partly quantization noise from the signal. In this embodiment the feedback signal 304 is taken from the output of the filter circuit 303. In this exemplary embodiment the feedback signal 304 is filtered so as to correspond to the frequency range of the input signal IN. In the next step, the filtered feedback signal is A/D-converted, and a necessary number of bits is added to the result of the A/D conversion so that it can be compared to the input signal IN of which a sample signal 306 has been taken for the comparison. On the basis of the comparison a difference signal is generated and then differentiated in order to give the rate and direction of change of the difference signal. The difference signal is processed at least on the basis of current change information. Change information of earlier difference signals may also be utilized in the processing. The processed difference signal is taken to the modulator circuit 301 in which the internal reference levels of the circuit, such as a sigma-delta modulator, can be changed on the basis of the processed difference signal. It is obvious to a person skilled in the art that the comparator circuit 305 in Fig. 5 comprises the same elements as the comparator circuit shown in Fig. 4. For simplicity, these elements are not shown in Fig. 5.

The modulator circuit 101 described above is arranged so as to realize pulse density modulation on the input signal. It is obvious to one skilled in the art that the modulator circuit 101 may also utilize modulation methods that can be applied in an arrangement according to the invention. One such modulation method is pulse width modulation. Of the various pulse width modulation methods it is possible to choose e.g. a method in which the pulse width is increased symmetrically in time from the pulse center point, or a method in which the pulse width is increased only in one temporal direction.

Fig. 6 shows a modulator circuit 301 according to the invention. An input signal IN is fed via a summing element 501 to an integrator 502. In the integrator the input signal IN is integrated and the integrated signal is then used to generate by means of a comparator 503 a pulsed signal which is output from the modulator circuit 301 as an output signal OUT2. The output signal OUT2 is taken to a feedback circuit 504. Also a processed difference signal generated in the comparator circuit 305 is given as a control signal to the feedback circuit 504. According to an advantageous embodiment of the invention the output signal OUT2 and the processed difference signal are summed together into a signal to be amplified. Other arrangements, too,

are possible. The feedback circuit 504 is used to generate a signal that is summed to the input signal IN of the modulator circuit 301 in the summing element 501. This way it is possible to reduce errors caused by modulation in the output of the modulator circuit 301 and, thereby, improve the operation of the whole output stage.

It is obvious to a person skilled in the art that delays can be advantageously reduced by processing the reference levels in the modulator circuit 301 by means of a control signal. This is a markedly faster solution than one in which the difference signal is added direct to the input signal because in this solution the difference signal and hence the control signal is updated more often than the input signal. The lengths of delays can also be affected by carefully selecting the point from which the feedback signal is taken.

Fig. 7 shows a block diagram of a mobile station according to an exemplary embodiment of the invention, in which the solution according to the invention is applied. The mobile station comprises typical parts, such as a microphone 601, keypad 607, display 606, earphone 617, transmit/receive switch 608, antenna 609, and a control unit 605. Additionally, the figure shows transmitter and receiver blocks 604, 611 typical of a mobile station. The transmitter block 604 comprises functions needed in speech encoding, channel encoding, encryption and modulation as well as the RF functions. The receiver block 611 comprises the corresponding RF functions as well as the functions needed in demodulation, decryption, channel decoding and speech decoding. A signal coming from the microphone 601, amplified in an amplifier stage 602 and converted to digital form in an A/D converter, is taken to the transmitter block 604, typically to a speech encoding element in the transmitter block. Having been processed, modulated and amplified in the transmitter block the signal is taken via the transmit/receive switch 608 to the antenna 609. A received signal is brought from the antenna via the transmit/receive switch 608 to the receiver block 611 which demodulates, decrypts and channel decodes the received signal. In a mobile station according to the invention the signal is taken from the receiver block 611 to the output stage 612. In stereo and 3D sound applications the output stage may be multiplied, but this does not affect the principle of the invention. The output stage 612 comprises a first means 613 to modulate a signal using pulse density modulation, for example. Such a means may be realized with a digital sigma-delta modulator, for instance. The output stage 612 of the mobile station further comprises a second means 614 to amplify the modulated signal. Such a means 614 may comprise a class D amplifier circuit, for example. The amplified signal is filtered using a third means 615, say a low-pass filter. The mobile station

according to the invention also comprises a means 616 to realize control for the modulation in the first means 613. The magnitude of the control signal 307 is determined in a comparator circuit 305 the feedback signal of which is in a first embodiment taken from the output of the second means 614. In a second advantageous embodiment the feedback is taken from the output of the third means 615. Advantageously the input signal of the output stage 612 is also used to determine the control signal 307. By comparing the input signal and feedback signal and by suitably processing the result of the comparison a digital control signal 307 for the first means 613 is advantageously generated with which the operation of the first means can be improved. The output signal of the output stage 612 is further taken to the earphone 617. The control unit 605 controls the operation of the mobile station, reads commands entered by the user on the keypad 607 and sends messages to the user through the display 606.

It is obvious to a person skilled in the art that the solution according to the invention finds particular utility in digital mobile communication systems such as GSM (Global System for Mobile communications). The invention may also be applied in future digital mobile communication systems such as UMTS (Universal Mobile Telecommunication System).

It is obvious to one skilled in the art that the solution according to the invention finds particular utility in digital loudspeakers, too, because in such loudspeakers the input signal is a serial digital word and the amplifier proper is located in the loudspeaker so that the usual filter can be advantageously left out. In such an application the both embodiments of the invention take the feedback from the same point.

In the modulator circuit, signal modulation may be realized with modulation methods other than pulse density modulation as far as they are applicable in the solution according to the invention. One such method is pulse width modulation.

It is obvious to a person skilled in the art that in a solution according to the invention in which the feedback signal directly affects the modulator reference levels it is possible to have the advantage that possible supply voltage fluctuations in the output stage can be compensated for. Delays in the circuit can also be reduced with the solution according to the invention.

The invention is not limited solely to the embodiments described above but the inventional idea disclosed here may be applied within the scope of the inventional idea defined by the claims attached hereto.

Claims

1. A method for improving the quality of the output signal of an audio output stage, which comprises at least a modulator circuit (301), **characterized** in that

- a signal generated in the audio output stage, which signal is proportional to a previous digital input signal, is compared by means of feedback to the digital input signal (IN) of the audio output stage in order to generate a digital control signal (307), and

- the operation of said modulator circuit (301) is controlled by means of said digital control signal (307).

2. The method according to claim 1, **characterized** in that the digital control signal (307) is used to change at least one reference level in the modulator circuit (301) of the audio output stage.

3. The method according to claim 1, **characterized** in that said signal generated in the audio output stage proportional to a previous digital input signal is filtered so as to correspond to the frequencies of the digital input signal in order to realize said comparison in the feedback.

4. The method according to claim 3, **characterized** in that in the feedback circuit bits are added to the filtered signal proportional to a previous digital input signal so that said signal will correspond to the digital input signal (IN) as regards the number of bits.

5. The method according to claim 1, **characterized** in that in the feedback circuit the signal proportional to a previous digital input signal is synchronized with the clock frequency of the input signal (IN).

6. The method according to claim 1, **characterized** in that said digital control signal is generated more often than said digital input signal changes.

7. The method according to claim 1, **characterized** in that the method is comprised of steps in which

- a digital input signal brought to the output stage is converted into a pulse train by means of modulation,

- said pulse train is amplified,

- said pulse train is filtered in the feedback circuit to a frequency range corresponding to the input signal,

- the filtered pulse train is converted into a digital signal in the feedback circuit,

- bits are added to said digital signal so that it corresponds to the input digital word as regards the number of bits,

- said input digital word and said digital signal are compared so as to produce a difference signal,

- change data for the digital difference signal are determined, and

- on the basis of said change data the conversion of the input digital word of the output stage into a pulse train is controlled by means of a digital control signal (307).

8. The method according to claim 1, **characterized** in that the method is comprised of steps in which

- a digital input word brought to the output stage is converted into a pulse train by means of modulation,

- said pulse train is amplified,

- said pulse train is filtered so as to make it suitable for output means,

- said pulse train filtered suitable for the output means is filtered in the feedback circuit to a frequency range corresponding to the input signal,

- the filtered pulse train is converted into a digital signal in the feedback circuit,

- bits are added to said digital signal so that it corresponds to the input digital word as regards the number of bits,

- said input digital word and said digital signal are compared so as to produce a difference signal,

- change data for the digital difference signal are determined, and

- on the basis of said change data the conversion of the input digital word of the output stage into a pulse train is controlled by means of a digital control signal (307).

9. The method according to claim 7 or 8, **characterized** in that the modulation is performed using pulse density modulation.

10. The method according to claim 7 or 8, **characterized** in that the modulation is performed using pulse width modulation.

11. An audio output stage for improving the quality of an output signal, which audio output stage comprises

- a modulator circuit (301) for modulating a digital input signal (IN),

- an amplifier circuit (302) for amplifying the modulated signal,

- a filter circuit (303) for filtering the modulated and amplified signal,

characterized in that the audio output stage further comprises a comparator circuit (305) for comparing the digital input signal (IN) and a signal generated in the output stage, which signal is proportional to a previous digital input signal, and for generating a digital control signal (307) for the modulator circuit (301).

12. The audio output stage according to claim 11, **characterized** in that the signal generated in the audio output stage is brought to the comparator circuit (305) from the output of the amplifier circuit (302).

13. The audio output stage according to claim 11, **characterized** in that the signal generated in the audio output stage is brought to the comparator circuit (305) from the output of the filter circuit (303).

14. The audio output stage according to claim 11, **characterized** in that said modulator circuit (301) is a sigma-delta converter.

15. The audio output stage according to claim 11, **characterized** in that said amplifier circuit (302) is a class D amplifier.

16. The audio output stage according to claim 11, **characterized** in that said filter circuit (303) is a low-pass filter.

17. The audio output stage according to claim 11, **characterized** in that said comparator circuit (305) comprises

- a means (314) to filter a feedback signal,

- a means (308) to A/D convert the filtered feedback signal (304),

- a means (309) to add bits in the A/D-converted feedback signal,

- a means (310) to synchronize the A/D-converted and bit-added feedback signal with the input signal (IN),

- a means (311) to compare the A/D-converted, bit-added and synchronized feedback signal to the input signal (IN) in order to produce a difference signal,

- a means (312) to process said difference signal, and

- a means (313) to convert said difference signal into a suitable control signal (307) on the basis of the result of the difference signal processing.

18. A mobile station comprising an audio output stage (612) for processing a received audio signal, **characterized** in that the audio output stage (612) of the mobile station comprises

- a first means (613) to modulate a digital signal,

- a second means (614) to amplify a modulated signal,

- a third means (615) to filter a modulated and amplified signal,

- a fourth means (616) to generate a digital control signal (307) by comparing the input signal (IN) to a signal generated in the output stage, which signal is proportional to a previous digital input signal, and by processing the signal which is the result of the comparison in such a manner that it becomes a digital control signal suitable for the first means (613).

19. The mobile station according to claim 18, **characterized** in that said mobile station belongs to a digital mobile communication system.

(57) Abstract

The invention relates to a method for improving the quality of the output signal of especially an audio output stage, which comprises at least a modulator circuit, in such a manner that in accordance with the method a signal generated in the output stage, which signal is proportional to a previous digital input signal, is compared by means of feedback to the digital input signal (IN) of the output stage in order to generate a digital control signal (307), and the operation of said modulator circuit (301) is controlled by means of said digital control signal (307). The invention further relates to an audio output stage which comprises a modulator circuit (301) to modulate a digital input signal (IN), amplifier circuit (302) to amplify a modulated signal, and a filter circuit (303) to filter a modulated and amplified signal, and which audio output stage further comprises a comparator circuit (305) for comparing the digital input signal (IN) and a signal generated in the output stage, which signal is proportional to a previous digital input signal, and for generating a digital control signal (307) for the modulator circuit (301).

Fig. 4

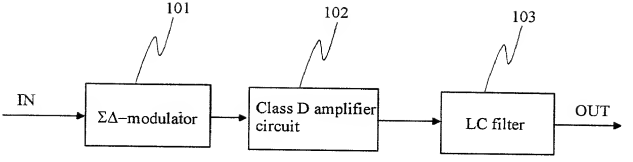

Fig. 1
PRIOR ART

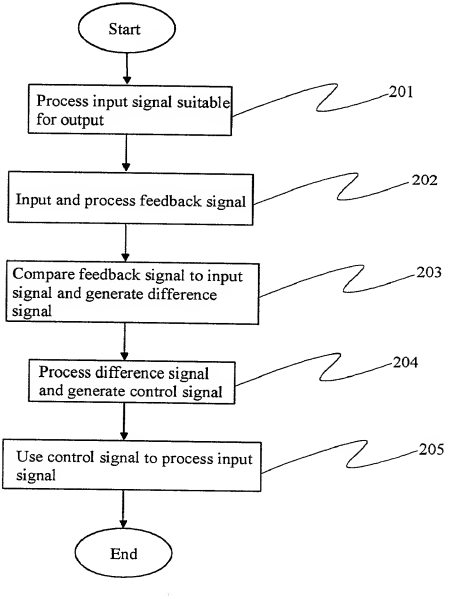

Fig. 2

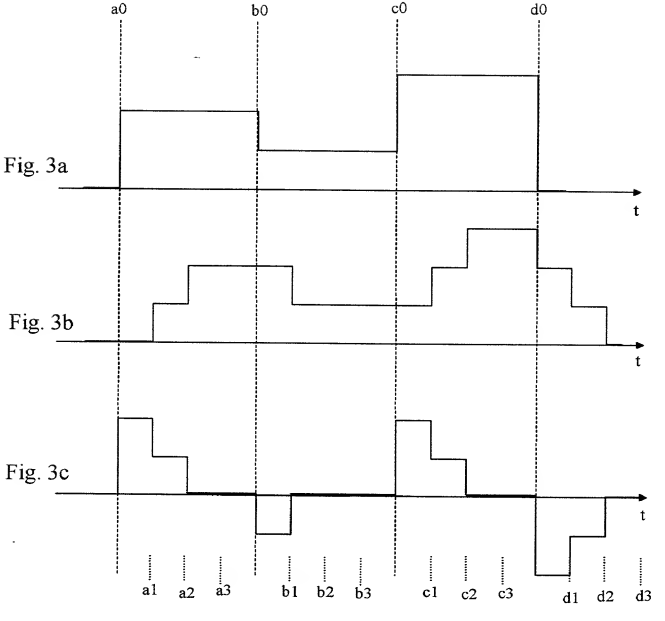

Fig. 3a

Fig. 3b

Fig. 3c

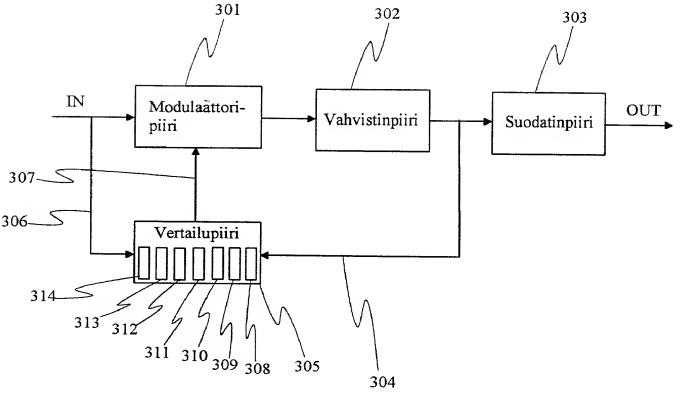
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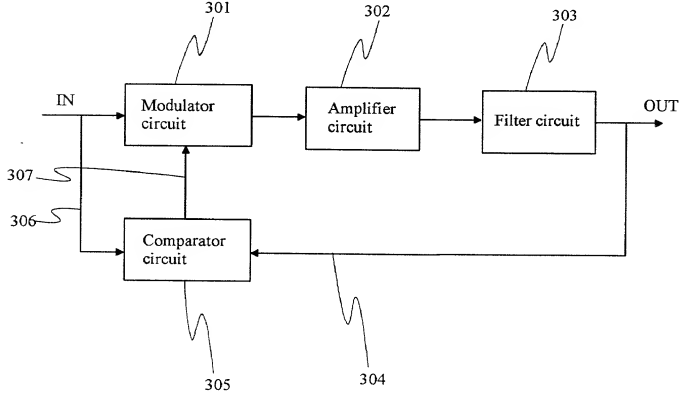
Fig. 4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Amplifier
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Filter circuit
OUT
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306
Comparator
circuit
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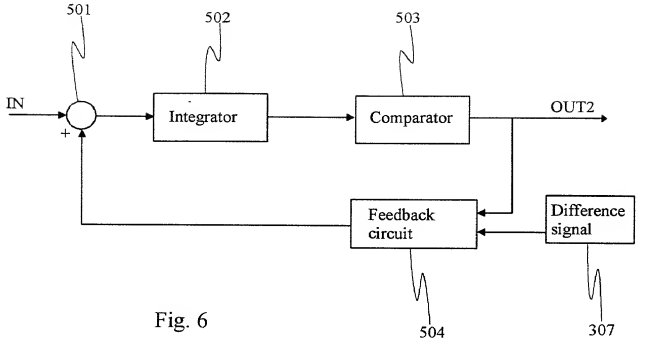
Fig. 5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502
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IN
+
Integrator
Comparator
OUT2
Feedback circuit
Difference signal
504
307

Fig. 6

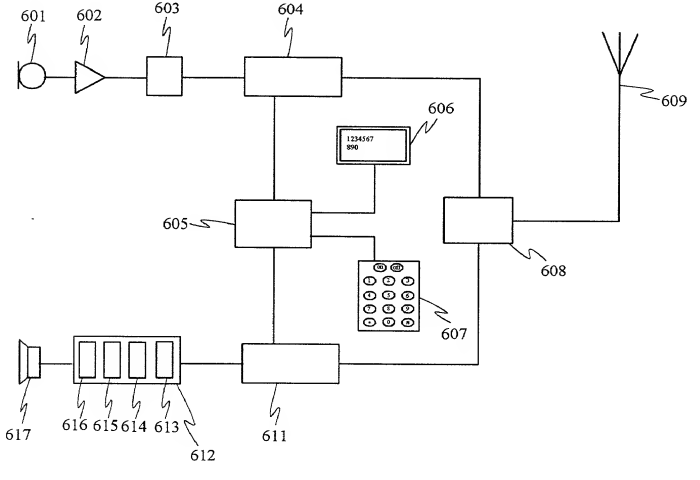
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Fig. 7

Attorney's Docket No. **PATENT**

COMBINED DECLARATION AND POWER OF ATTORNEY (ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION OR C-I-P)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

(check one applicable item below)

X original.
__ design.
__ supplemental.

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

__ national stage of PCT.

NOTE: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

__ divisional.
__ continuation.
__ continuation-in-part (C-I-P).

INVENTORSHIP IDENTIFICATION

WARNING: If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

TITLE OF INVENTION

Improvement of signal quality

SPECIFICATION IDENTIFICATION

the specification of which:

(complete (a), (b) or (c))

(a) X is attached hereto.

(b) ___ was filed on _____, as X Serial No.
or __ Express Mail No., as Serial No. not yet known _____
and was amended on_____*(if applicable).*

NOTE. Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 CFR 1.67.

(c) __ was described and claimed in PCT International Application No._____, filed on _____ and as amended under PCT Article 19 on _____ *(if any).*

ACKNOWLEDGEMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

(also check the following items, if desired)

X and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent. and

__ in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 CFR 1.98.

PRIORITY CLAIM (35 U.S.C. § 119(a)-(d))

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) __ no such applications have been filed.

(e)X such applications have been filed as follows.

NOTE. Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)

COUNTRY(OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 37 USC 119	
Finland	19992540	26 November 1999	XYES	NO__
			__YES	NO__
			__YES	NO__
			__YES	NO__
			__YES	NO__

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S) (34 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER	FILING DATE
_____/_____	_____
_____/_____	_____
_____/_____	_____

CLAIM FOR BENEFIT OF EARLIER US/PCT APPLICATION(S) UNDER 35 U.S.C. 120

__ The claim for the benefit of any such applications are set forth in the attached ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN PART (C-I-P) APPLICATION.

ALL FOREIGN APPLICATION(S), *IF ANY*, FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

_____

_____

_____

NOTE. If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S. or PCT application(s) under 35 U.S.C. § 120.

POWER OF ATTORNEY

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

(list name and registration number)

Clarence A. Green (24,622)
Harry F. Smith (32,493)
Mark F. Harrington (31.686)

(check the following item, if applicable)

__ Attached, as part of this declaration and power of attorney, is the authorization of the above-named attorney(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE TO DIRECT TELEPHONE CALLS TO:
(Name and telephone number)
Clarence A. Green Clarence A. Green
Perman & Green 203-259-1800
425 Post Road
Fairfield, Ct 06430

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that wilful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such wilful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other documents.

Full name of sole or first inventor:
Given name: Juha
Middle initial or name:
Family (or last name): NURMINEN

Inventor's signature: _____
Date: 8.11.2000
Country of Citizenship: Finland
Residence: ~~Sokerilinnantie 4 C 54, FIN-02600 ESPOO, Finland~~ ALLEGTIE 9C
Post Office Address: ~~Sokerilinnantie 4 C 54, FIN-02600 ESPOO, Finland~~ 00 660 HELSINKI, FINLAND

Full name of second joint inventor, if any:
Given name:
Middle initial or name:
Family (or last name):

Inventor's signature: _____
Date: _____
Country of Citizenship:
Residence:
Post Office Address:

Full name of third joint inventor, if any:
Given name:
Middle initial or name:
Family (or last name):
Inventor's signature: _____
Date: _____
Country of Citizenship:
Residence:
Post Office Address:

(check proper box(es) for any of the following added page(s) that form a part of this declaration)

__ **Signature** for fourth and subsequent joint inventors. *Number of pages added* _____.

* * *

__ **Signature** by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* _____.

* * *

__ **Signature** for inventor who refuses to sign or cannot be reached by person authorized under 37 CFR 1.47. *Number of pages added* _____.

* * *

__ Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time. (37 CFR 1.47)

* * *

__ Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application.
__ Number of pages added_____

* * *

__ Authorization of attorney(s) to accept and follow instructions from representative.

* * *

(if no further pages form a part of this Declaration, then end this Declaration with this page and check the following item)
X This declaration ends with this page.